Assimilation of TerraSAR-X data into a snowpack model

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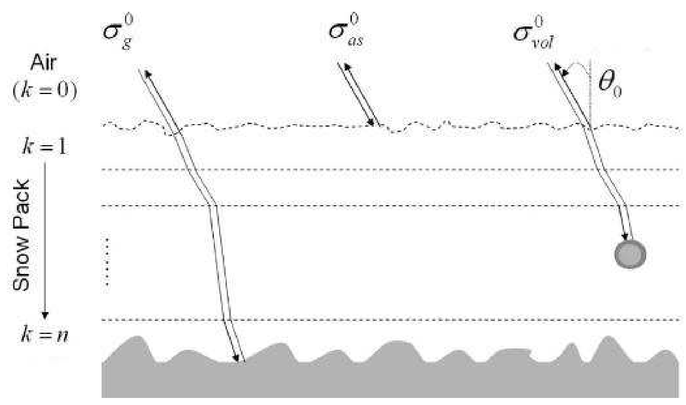
OBJECTIVES

- Implementation of a multilayer snowpack electromagnetic backscattering model (EBM), based on Dense Media Transfer Radiative (DMRT), at high frequency bands (X-band and above).
- Application of 3D-VAR data assimilation to constrain the snow metamorphism model Crocus using SAR image data and the EBM.

ELECTROMAGNETIC BACKSCATTERING MODEL

- The simulated snowpack backscattering consists of 3 main backscattering mechanisms:

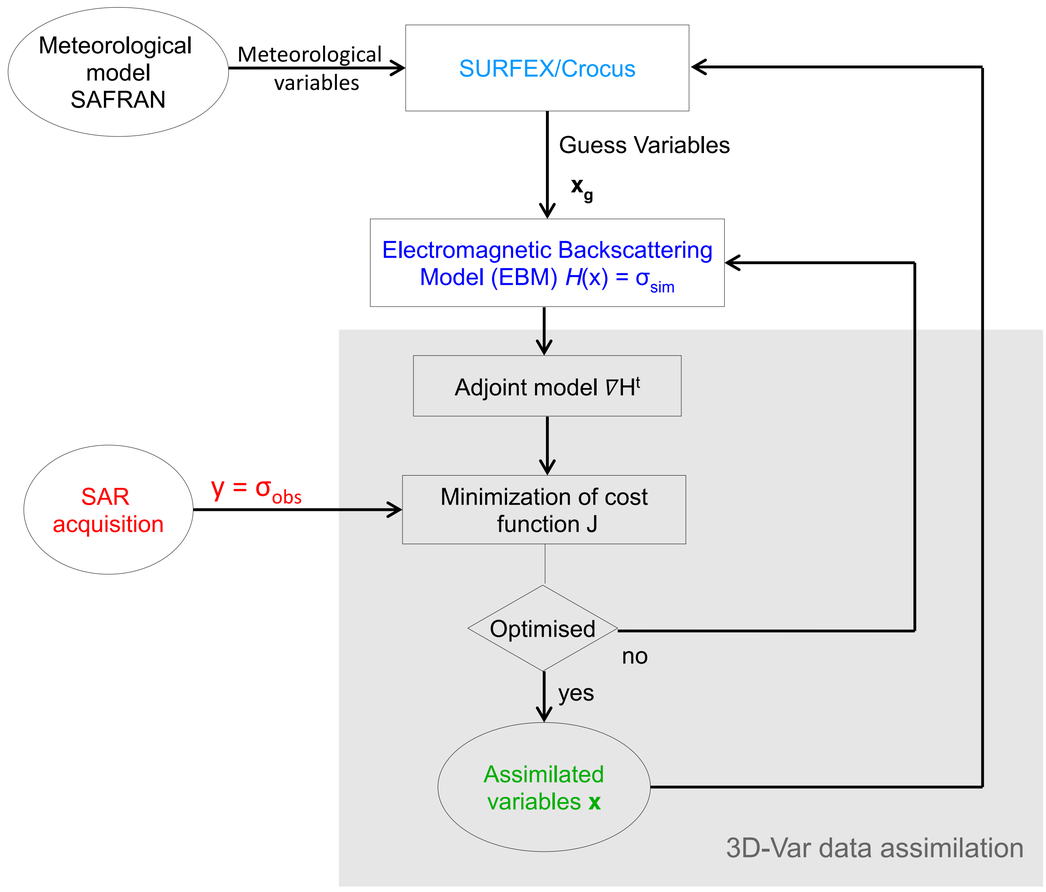
$$\sigma^0_{sim} = \sigma^0_{as} + \sigma^0_{vol} + \sigma^0_g$$



- σ^0_{as} and σ^0_g are calculated using Integral Equation Model (IEM).

- σ^0_{vol} - Total volume backscattering of all snowpack layers, derived from DMRT equations.

3D-VAR DATA ASSIMILATION



3D-VAR assimilation adjusts the guess parameters to reduce the discrepancy between σ_{sim} and σ_{TSX}, according to the error statistics of modeling and observations.

In order to constrain the initial guess data using the observations, one needs to minimize the cost function J:

$$J = (\mathbf{x} - \mathbf{x}_g)^t \mathbf{B}^{-1} (\mathbf{x} - \mathbf{x}_g) + (\mathbf{y} - H(\mathbf{x}))^t \mathbf{R}^{-1} (\mathbf{y} - H(\mathbf{x}))$$

where :

- $\mathbf{x}_g$ and **x** - the initial guess and analysed snowpack parameters, contains the values of density and grain size of each snow layer.
- **y** and $H(\mathbf{x})$ - SAR calibrated backscattering (σ_{TSX}) and simulated backscattering coefficient (σ_{sim}).
- **B** and **R** - the error covariance matrices of Crocus and observations.

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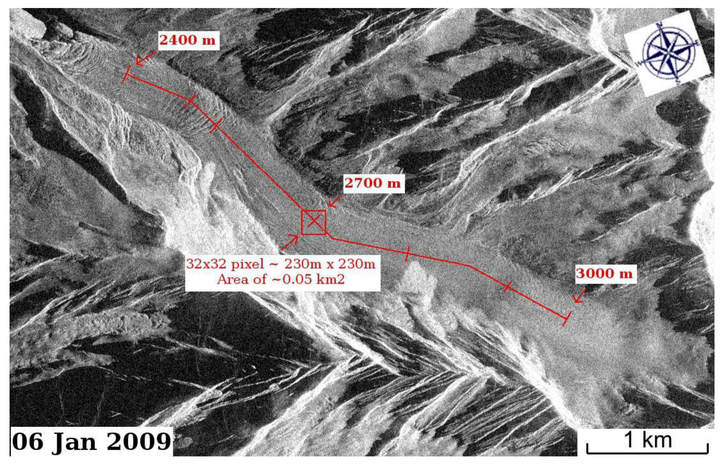
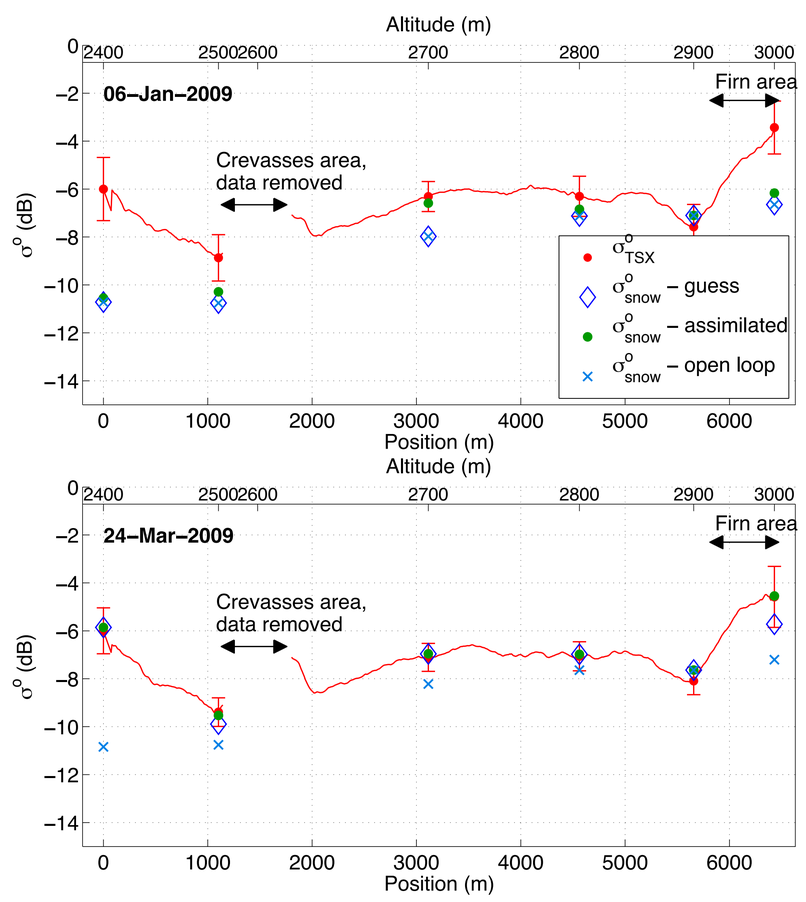
CASE STUDY: ARGENTIÈRE GLACIER

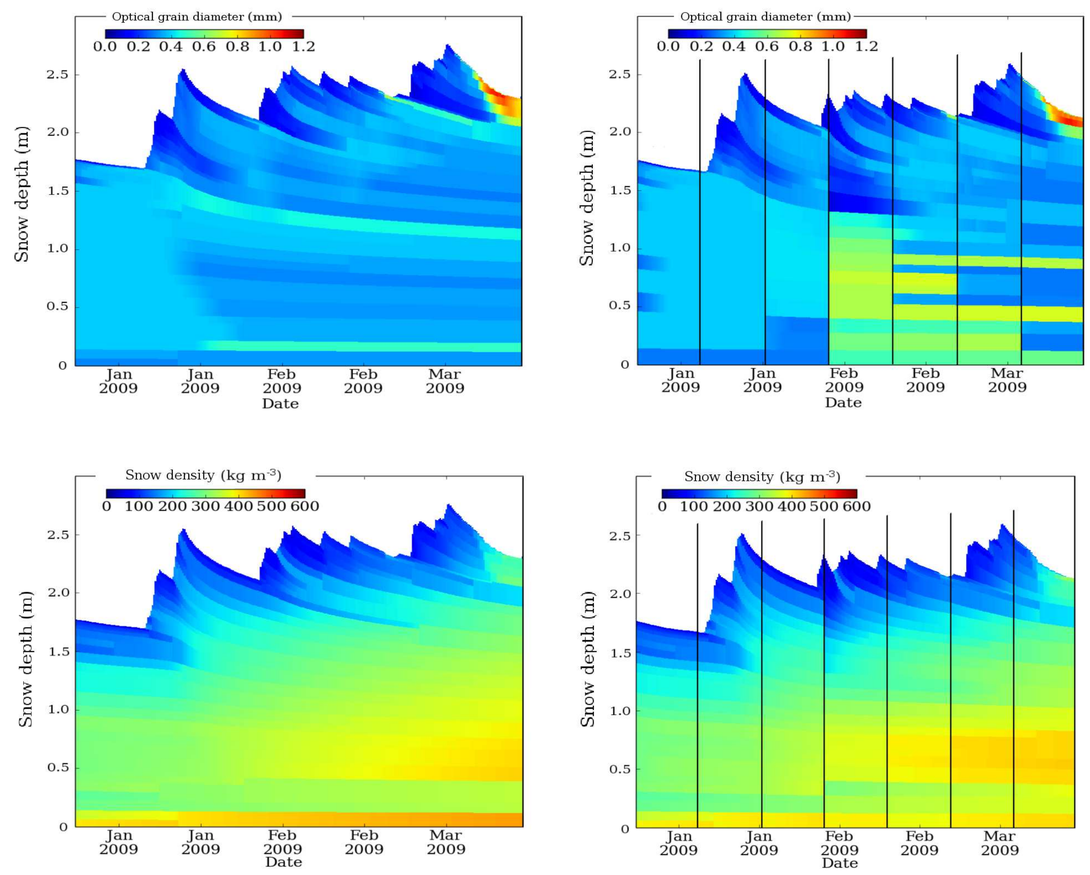
- A total of 8 TerraSAR-X descendant acquisitions are available in 2009 from January 6th to March 24th. Crocus simulations are executed from August 1st, 2008 to August 1st, 2009.



TerraSAR-X image of Argentière glacier.



Results of simulation and data assimilation on Argentière glacier.



Without assimilation *With assimilation*

3D-VAR data assimilation on each layer of Crocus snow profiles.

CONCLUSION

- Through the use of 3D-VAR data assimilation and the EBM, we are able to constrain the snowpack evolution model Crocus using external remote sensing data from TerraSAR-X satellite.
- Future work will be concentrated on the validation of the proposed method on a large number of in-situ measurements.